WHAT IS CLAIMED IS:

1. An optical sensor comprising:

a light source having an output that emits a first optical signal;

a directional coupler comprising at least a first port, a second port and a third port, the first port optically coupled to the light source to receive the first optical signal emitted from the light source, the first port optically coupled to the second port and to the third port such that the first optical signal received by the first port is split into a second optical signal output by the second port and a third optical signal output by the third port;

a hollow-core photonic-bandgap fiber having a hollow core surrounded by a cladding, the hollow-core photonic-bandgap fiber optically coupled to the second port and to the third port such that the second optical signal and the third optical signal counterpropagate through the hollow-core photonic-bandgap fiber and return to the third port and the second optical port, respectively, the cladding of the hollow-core photonic-bandgap fiber substantially confining the counterpropagating second optical signal and third optical signal within the hollow core; and

an optical detector located at a position in the optical instrument to receive the counterpropagating second and third optical signals after the second and third optical signals have traversed the hollow-core photonic-bandgap fiber.

2. The optical sensor of Claim 1, wherein the light source comprises a broadband source outputting light having a spectral distribution with a full width at half maximum of about 1 nanometer or larger.

3. The optical sensor of Claim 2, wherein the light source comprises a superfluorescent light source.

4. The optical sensor of Claim 3, wherein the light source mean wavelength is stable to at least about ±100 parts per million.

5. The optical sensor of Claim 3, wherein the light source mean wavelength is stable to at least about ±10 parts per million.

6. The optical sensor of Claim 3, wherein the light source mean wavelength is stable to at least about ±1 part per million.

7. The optical sensor of Claim 3, wherein the light source mean wavelength is stable to at least about ±0.1 part per million.

8. The optical sensor of Claim 3, wherein the superfluorescent light source comprises a superluminescent fiber source.

9. The optical sensor of Claim 3, wherein the superfluorescent light source comprises a light-emitting diode.

10. The optical sensor of Claim 2, wherein the light source comprises a broadband fiber laser.

11. The optical sensor of Claim 1, wherein the light source comprises a broadband source outputting light having a spectral distribution with a full width at half maximum of between about 1 nanometer and about 10 nanometers.

12. The optical sensor of Claim 1, further comprising an amplitude modulator that modulates the amplitude of the first optical signal output from the light source.

13. The optical sensor of Claim 12, wherein the amplitude modulator is external to the light source.

14. The optical sensor of Claim 1, further comprising a frequency modulator that modulates the frequency of the first optical signal output from the light source.

15. The optical sensor of Claim 12, wherein the frequency modulator is external to the light source.

16. The optical sensor of Claim 1, wherein the light source comprises a narrowband source that outputs light having a spectral distribution with a full width at half maximum of less than 1 nanometer.

17. The optical sensor of Claim 16, wherein the narrowband light source comprises a fiber laser.

18. The optical sensor of Claim 16, wherein the narrowband light source comprises a semiconductor laser diode.

19. The optical sensor of Claim 16, wherein the light source mean wavelength is stable to at least about ±100 parts per million.

20. The optical sensor of Claim 16, wherein the light source mean wavelength is stable to at least about ±10 parts per million.

21. The optical sensor of Claim 16, wherein the light source mean wavelength is stable to at least about ±1 part per million.

22. The optical sensor of Claim 16, wherein the light source mean wavelength is stable to at least about ±0.1 part per million.

23. The optical sensor of Claim 1, wherein the hollow-core photonic-bandgap fiber comprises polarization-maintaining photonic-bandgap fiber.

24. The optical sensor of Claim 1, wherein photonic-bandgap fiber comprises a plurality of features arranged in a periodic array across a cross-section of the hollow-core photonic-bandgap fiber that surrounds the hollow core.

25. The optical sensor of Claim 1, wherein photonic-bandgap fiber comprises a Bragg fiber.

26. The optical sensor of Claim 1, wherein the hollow-core photonic-bandgap fiber cladding comprises a silica-based glass.

27. The optical sensor of Claim 26, wherein the cladding further comprises a periodic array of channels in the silica-based glass.

28. The optical sensor of Claim 27, wherein the channels are hollow.

29. A method for sensing comprising:

producing light having a mean wavelength, λ, the light being divided into two portions;

propagating a first portion of the light clockwise around a hollow waveguide, and propagating a second portion of the light counterclockwise around the hollow waveguide;

substantially confining the first and second portions of light to propagation through a hollow core in the hollow waveguide by a cladding having a photonic-bandgap structure for the light;

optically interfering the first and second portions of light after propagating the first and second portions of light around the hollow waveguide in the respective clockwise and counterclockwise directions, thereby producing an optical interference signal;

subjecting the hollow waveguide to a perturbation; and

measuring variations in the optical interference signal caused by the perturbation.

30. The method of Claim 29, wherein the first and second portions of light are substantially confined to the hollow core, thereby reducing backscattering.

31. The method of Claim 30, wherein at least about 90% of the light is confined to the hollow core.

32. The method of Claim 30, wherein at least about 95% of the light is confined to the hollow core.

33. The method of Claim 30, wherein at least about 99% of the light is confined to the hollow core.

34. The method of Claim 29, wherein the first and second portions of light are substantially confined to a region in the hollow core comprising air.

35. The method of Claim 29, wherein the first and second portions of light are substantially confined to a region in the hollow core comprising vacuum.

36. The method of Claim 29, further comprising intensity modulating the light.

37. The method of Claim 29, further comprising intensity modulating the light at a duty cycle between 49% and 51%.

38. The method of Claim 29, further comprising intensity modulating the light at a duty cycle of about 50%.

39. The method of Claim 29, further comprising phase modulating the first and second portions of light propagating clockwise and counterclockwise through the optical path.

40. The method of Claim 39, further comprising frequency modulating the light with a modulation signal having a modulation frequency between about 1 Gigahertz and about 50 Gigahertz.

41. The method of Claim 39, further comprising frequency modulating the light with a modulation signal having a frequency of about 10 Gigahertz.

42. The method of Claim 29, wherein the perturbation comprises rotation.

43. The method of Claim 29, wherein the perturbation comprises pressure.

44. The method of Claim 29, wherein the perturbation comprises motion.

45. An optical instrument for sensing rotation comprising:

a light source having an output that emits a first optical signal having a mean wavelength, λ, stable to within at least about $\pm 10^{-6}$;

a directional coupler comprising at least a first port, a second port and a third port, the first port optically coupled to the light source to receive the first optical

signal emitted from the light source, the first port optically coupled to the second port and to the third port such that the first optical signal received by the first port is split into a second optical signal output by the second port and a third optical signal output by the third port;

a hollow-core photonic-bandgap fiber having a hollow core surrounded by a cladding, the hollow-core photonic-bandgap fiber optically coupled to the second and third ports such that the second and third optical signals output from the second and third ports counterpropagate through the hollow-core photonic-bandgap fiber and return to the third and second optical ports respectively, the cladding of the hollow-core photonic-bandgap fiber substantially confining the counterpropagating second and third optical signals within the hollow core; and

an optical detector located at a position in the optical instrument to receive the counterpropagating second and third optical signals after the second and third signals have traversed the hollow-core photonic-bandgap fiber.

46. A method for sensing rotation comprising:

producing light having a substantially invariant mean wavelength, λ, which varies no more than about $\pm 10^{-6}$;

propagating a first portion of the light clockwise around a optical path, and propagating a second portion of the light counterclockwise around the optical path;

substantially confining the first and second portions of light to propagation through the optical path by a photonic-bandgap structure for light;

optically interfering the first and second portions of light after propagating the first and second portions of light around the optical path in the respective clockwise and counterclockwise directions, thereby producing an optical interference signal;

at least partially rotating the optical path; and

measuring variations in the optical interference signal caused by the rotation.

47. An optical system comprising:

a light source having an output that emits a first optical signal;

a directional coupler comprising at least a first port, a second port and a third port, the first port optically coupled to the light source to receive the first optical

signal emitted from the light source, the first port optically coupled to the second port and to the third port such that the first optical signal received by the first port is split into a second optical signal output by the second port and a third optical signal output by the third port;

a hollow-core photonic-bandgap fiber having a hollow core surrounded by a cladding, the hollow-core photonic-bandgap fiber optically coupled to the second port and to the third port such that the second optical signal and the third optical signal counterpropagate through the hollow-core photonic-bandgap fiber and return to the third port and the second optical port, respectively, the cladding of the hollow-core photonic-bandgap fiber substantially confining the counterpropagating second optical signal and third optical signal within the hollow core; and

an optical detector located at a position in the optical instrument to receive the counterpropagating second and third optical signals after the second and third signals have traversed the hollow-core photonic-bandgap fiber.

48. An interferometer comprising:

a light source having an output that emits a first optical signal having a mean wavelength, λ, stable to within at least about $\pm 10^{-6}$;

a directional coupler comprising at least a first port, a second port and a third port, the first port optically coupled to the light source to receive the first optical signal emitted from the light source, the first port optically coupled to the second port and to the third port such that the first optical signal received by the first port is split into a second optical signal output by the second port and a third optical signal output by the third port;

a hollow-core photonic-bandgap fiber having a hollow core surrounded by a cladding, the hollow-core photonic-bandgap fiber optically coupled to the second and third ports such that the second and third optical signals output from the second and third ports counterpropagate through the hollow-core photonic-bandgap fiber and return to the third and second optical ports respectively, the cladding of the hollow-core photonic-bandgap fiber substantially confining the counterpropagating second and third optical signals within the hollow core; and

an optical detector located at a position in the optical instrument to receive the counterpropagating second and third optical signals after the second and third signals have traversed the hollow-core photonic-bandgap fiber.